CALCULATIONS OF H_2CO EMISSION IN MASSIVE ACCRETION DISKS WITH CONSIDERING LEVELS OF EXCITED VIBRATIONAL STATES.

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A high gas temperature and intense radiation field, which are present in accretion disks around massive stars, can lead to excitation of rotational levels of lower H_2CO excited vibrational states, thus affecting the intensity of rotational radio-transitions.

The aim of this work is to make a model of molecular rotational levels and transitions of H_2CO ground and excited vibrational states (hereafter, ground and excited levels, respectively) and to use this model for radiative transfer calculations in H_2CO lines in accretion discs.

For calculations, we have used molecular data (level energies, statistical weights and quantum numbers, Einstein coefficients) that were taken from the ExoMol database [1]. With these data, we have selected ground and excited levels with energies lower than 1000 sm^{-1} and 1500 sm^{-1}, respectively. Moreover, we required that excited levels should be linked with ground levels by radiative transitions. We have used an artificial neural network (ANN) and the set of already known collisional rates for transitions between ground levels to estimate the collisional rates for transitions that involve excited states by extrapolation. The training of the ANN was conducted on a subset of the set of transitions for which collisional rates are known, and the following testing was performed using the other part of that transitions set. The ANN consisted of three layers: input, hidden and output of three, sixteen and one neurons, respectively. The input parameters were the differences of energies and two rotational quantum numbers between the initial and final states of a given transition. The relative accuracy of the calculations provided by ANN is 0.1.

Then, obtained model of molecular levels and transitions was used for radiative transfer calculations in H_2CO lines in approximation of large velocity gradient. These calculations were performed with the published model of accretion disk around massive binary star [2].

Preliminary results showed that the inclusion of levels from excited vibrational states could significantly affect the optical thickness in rotational transitions. Under the same physical conditions, the inclusion of excited levels into molecular model could lead to a change of optical thickness sign from positive to negative, i.e. it could lead to a maser amplification.

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1. Al-Refaie A. F., Yachmenev A., et al., MNRAS, 448, 1704-1714 (2015).
2. Parfenov S.Yu., Sobolev A.M., MNRAS, 444, 620-628 (2014).